HARDINESS IN SUCCESSIVE ALFALFA GENERATIONS

L. R. WALDRON

DICKINSON, NORTH DAKOTA

IN 1908 Mr. Charles J. Brand, of the Department of Agriculture, inaugurated an experiment in alfalfa to determine, among other things, the relations that different strains of alfalfa have to the cold of severe winters. The writer aided in this investigation.

For this purpose 68 regional strains of alfalfa were assembled from the various alfalfa regions of the world, many of them being foreign in immediate origin. The alfalfas were planted in hill and drill rows, and during the season of 1908 the rows were thinned so that accurate countings could be made. There were in the neighborhood of 80 plants to each strain. The winter of 1908–09 was particularly severe to alfalfa, and as a consequence most of the strains were sadly deleted.[1]

Twelve of the 68 strains were entirely killed, no living plants remaining. Twenty-eight of the strains killed out over 90 per cent., and over 60 per cent. of the strains killed out over 80 per cent. There were but 3 of the 68 strains that killed out less than 10 per cent. The killing of the American alfalfas was severe as indicated by the fact that the 9 strains from Utah killed over 90 per cent., while the 3 Montana strains killed over 65 per cent.

The hardier strains were those of more recent foreign origin. Two strains of the Grimm alfalfa had an average killing of less than 5 per cent., thus being the hardiest in the nursery. Neglecting the 12 strains that killed out entirely, the average killing of the nursery amounted to 77.51 per cent., using each strain as a unit.

[1] Charles J. Brand and L. R. Waldron, "Cold Resistance of Alfalfa and Some Factors Influencing It," Bulletin 185, Bureau of Plant Industry, U. S. Department of Agriculture.

During the summer of 1909 the seed produced by the living plants was saved from each strain separately. In the spring of 1910 a sowing was made of the original seed that had sown the first nursery, which had been designated as nursery *A*. This sowing was known as series 201. In addition another sowing was made in 1910, known as series 202, from the seed collected from nursery *A* in 1909. This sowing was from seed secured from plants that had survived the severe winter of 1908–09. In addition a number of rows were sown with seed from nursery *A* plants, selfed during the summer of 1909.

This second experiment, carried on by the writer, consisted of a number of duplicate rows seeded (*a*) with seed from original geographical sources, and (*b*) rows seeded with daughter seed obtained from the plants surviving the winter of 1908–09. These two seedings comprised 112 150-foot rows, each row containing up to 150 plants. During the summer of 1910 the rows were thinned and accurate countings were made. In the spring of 1911, after growth was well started, a determination was made of the number of dead plants, and in addition the living plants were gauged as to their vigor, on a basis of 1 to 10, the best plants receiving the highest markings.

The data obtained indicated the apparent increase of hardiness among the different strains. A possible source of error was the effect of vicinism in nursery *A* in producing hardiness in the progeny plants constituting series 202. Limited space prevents presenting the evidence which would lead one to think that this error was slight in effect and probably nearly negligible.

Only a brief summary of the results can be presented in this article, a detailed account of which must be left to a future publication. In the first place, let us regard the comparative results of the winters of 1908–09 and 1910–11 upon the strains in nursery *A*, and upon those of series 201. These two sowings were from the same lot of seed, and had they been representative samples one

would have expected that they would have fared relatively the same in the two winters. Deviations that might appear could be charged to the differences of the two winters, as we may suppose that alfalfa becomes acclimated in different ways to different types of cold.

The relation of the killing of the plants in nursery *A* and in series 201 is presented in the correlation table of

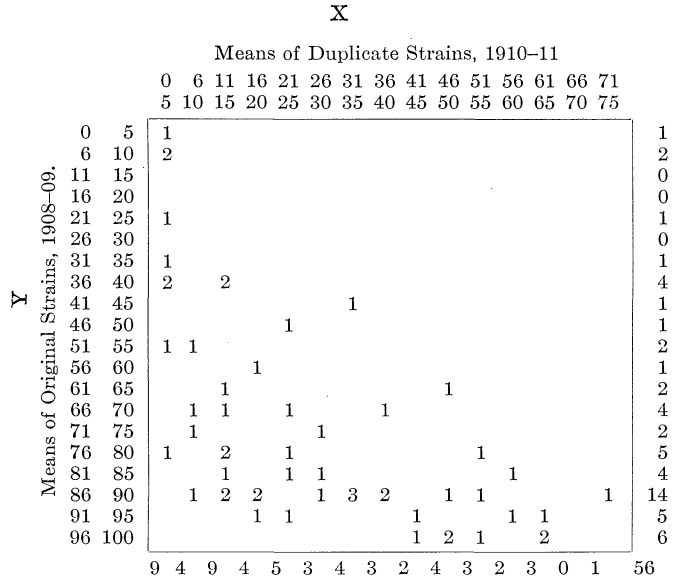

FIG. 1. Correlation of the means of various strains of alfalfa. Original nursery *A* seeding subject, duplicate of these strains in 201 series relative. Coefficient of correlation, $+0.62 \pm 0.06$. Standard deviation of *Y*, 24.85 ± 1.57. Standard deviation of *X*, 19.62 ± 1.24.

Fig. 1. The means of nursery *A* are the average per cents. of killing for the different strains, and the means of the duplicate seeding, series 201, are the corresponding per cents. for that nursery. In the table, the nursery *A* means appear as subject, and the means of series 201 appear as relative. The table shows good correlation amounting to $+0.62 \pm 0.06$, thus indicating that the two series of alfalfa were affected relatively the same by the two winters. This fact is perhaps more strikingly shown when the two series of means are platted on coordinate

paper. The ups and downs of one series correspond very closely with the ups and downs of the other series. The mean killing of series 201 was 27.43 ± 1.75 per cent. as against 77.51 ± 2.21 per cent. in nursery *A*, indicating that the second winter was the milder one.

The relation between the killing experienced by series 201 and series 202, during the 1910–11 winter, is expressed by the correlation table of Fig. 2. In this case the 201 series is subject and the 202 series is relative. The mean of the 202 series amounts to 6.43 ± 0.66. The correlation in the table amounts to $+0.46 \pm 0.07$. As

Y: Means of 201 Series	X: Means of 202 Series							
	0 5	6 10	11 15	16 20	21 25	26 30	31 35	
0 5	6	2	1					9
6 10	3	1						4
11 15	3	6						9
16 20	2		1	1				4
21 25	2		1	2				5
26 30	2	1						3
31 35	3	1						4
36 40		1			1	1		3
41 45	1			1				2
46 50	1	1		1			1	4
51 55		1	1		1			3
56 60		1		1				2
61 65	1	1		1				3
66 70								0
71 75					1			1
	24	16	4	7	3	1	1	56

FIG. 2. Correlation of the means of various strains of alfalfa. Duplicate seeding of nursery *A* (series 201) subject, progeny of the hardy plants of nursery *A* (series 202) relative. Coefficient of correlation, $+0.46 \pm 0.07$. Standard deviation of *Y*, 19.62 ± 1.24. Standard deviation of *X*, 7.35 ± 0.46.

indicated by the means of the two series, 27.43 and 6.43, there was a remarkable apparent increase in hardiness. This is partially expressed in the correlation table, but in the table the most pronounced changes do not work for a strong correlation.

For instance, one Utah strain killed out 59.6 per cent. in the 201 series, while its offspring killed but 6.2 per cent. in the 202 series. This indicates a weak correlation but a great increase in hardiness. There were but 3 instances of the 202 series killing more severely than the

201 series. Two of these instances were Turkestan alfalfas. The third one was due to the fact that the 202 row was an outer row, thus not afforded protection by an adjacent row.

In our theoretical discussion of the data we can scarcely more than present the problem. Within the limits of the pure *Medicago sativa,* as pure as it exists to-day, the fact is patent that there is a wide range of diversity in hardiness among the different strains of alfalfa, dependent in greatest measure upon their geographical origin. Strains of *Medicago sativa* that have been grown for long periods in cold climates, *e. g.,* Mongolian alfalfas, are found to be hardy during the severe winters of this country. Upon the other hand the strains of this species which have been grown for long periods in hot countries, *e. g.,* Arabia and Peru, were found to be exceedingly tender in cold districts. Thus at Dickinson, North Dakota, it has never been possible to bring alive through the winter a single plant of the Arabian alfalfas, and only under exceptionally favorable conditions has it been possible to winter any of the Peruvian alfalfa plants.

The diversity is so great between the Arabian and the Mongolian alfalfas that we must consider that hardiness has actually been added to the alfalfas which have become hardy, or that hardiness has been lost to alfalfas that have become tender.[2] It is not unlikely that changes have been brought about in both directions. The simple problem is, has this change come about through the "law of ancestral inheritance," or must the change be accounted for by distinct mutations occurring within any particular strain of alfalfa? Or is it possible that changes have come about through conformity to both methods?

[2] The fact is not lost sight of that an increase of hardiness may possibly be brought about by a recombination of certain (at present unknown) morphological characters physically responsible in different ways for the presumably complex character of hardiness. See Nilsson-Ehle, "Kreuzungsuntersuchungen," Lunds Univ. Ars., Bd. 5, Nr. 2, p. 114. Also a forthcoming article by the writer in the *American Breeders' Magazine.*

The belief that any strain of alfalfa is made up of many substrains with various steps of hardiness has been arrived at largely by *a priori* methods. We find that there are distinct morphological types of alfalfa within a strain which breed true, and that with other plants there are physiological types within any strain or variety likewise breeding true. It is reasonable to suppose that the same is true in regard to hardiness in alfalfa.

One of the Utah strains of the 201 series killed 42.8 per cent. from a total of 76 plants, and at the same time this strain of the 202 series sown from seed secured from three mother plants killed but 3.5 per cent. from a total of 131 plants. We have established at once a comparatively hardy alfalfa from one quite tender. With this Utah alfalfa, as with several others, it is difficult to avoid the conclusions that the strain is made up of many biotypes, relative to hardiness, which show their independent character even when no precaution is taken against interbreeding

We have also experimental evidence upon this point. Alfalfas that were selfed in 1909 were from both hardy and tender strains of alfalfa. A selfed Mexican plant had progeny that showed absolute hardiness during the winter of 1910–11, while the mother strain killed 24.5 per cent. Others of the selfed alfalfas acted in the same manner, producing offspring behaving radically different from the behavior of the parent strain. In some cases progenitors of non-hardy strains were selected from hardy strains.

It seems likely then that any regional strain of alfalfa as far as hardiness is concerned, is made up of biotypes with different cold resistant qualities. An alfalfa of this nature when moved to a colder region loses the representatives of the tender biotypes leaving the hardy ones for propagation. But this explanation accounts in no measure for the absolute changes of hardiness which some alfalfas must have undergone to have allowed the

species to accommodate itself to extreme climatic conditions.

While it is evident that there are alfalfas in existence to-day which do not contain elements of hardiness sufficient to allow them to live through the severer winters of the United States, this statement apparently does not hold for the alfalfas that are grown in the New World, with the exception perhaps of the alfalfa known as the Peruvian.[3]

Inasmuch as the South American alfalfas grown in hot regions contain elements capable of surviving very severe winters, it is apparently not necessary to assume recent mutative periods in the species. Inasmuch as the alfalfa plant grown in the New World contains elements of hardiness allowing it to persist through periods of severe cold, it is reasonable to assume that this element of extreme hardiness may be dissociated from the elements of lesser hardiness, even in the tenderest strains, in such a manner that it can be carried from generation to generation. This practical result has not yet been attained, not because such a result is theoretically impossible, but because no systematic attempt has been made. It is evidently a saner thing to commence practical breeding with those forms nearest to the one desired.

[3] Charles J. Brand, "Peruvian Alfalfa," Bulletin 118, Bureau of Plant Industry, U. S. Department of Agriculture. The Peruvian alfalfa is considered varietally distinct. This and the Arabian alfalfa have not as yet been found to possess elements capable of amelioration to the severe conditions of the north. Whether these two forms are retrograde mutants derived from the old alfalfa stock is impossible to determine at this time. One would be inclined to believe that such is the case.

The historically and long-continued growth of alfalfa in hot regions almost precludes the hypothesis of the loss of cold-resisting biotypes, which would obtain were the alfalfa strain transferred to a hotter region.